APPLICATION NO. 09/846,410

TITLE OF INVENTION: Multiple Data Rate Hybrid Walsh Codes for CDMA

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Currently amended Claims

APPLICATION NO. 09/846.410

TITLE OF INVENTION: Multiple Data Rate ~~Complex~~ Hybrid Walsh Codes for CDMA

INVENTOR~~S~~: Urbain A. von der Embse

CLAIMS

WHAT IS CLAIMED IS:

Claim 1. (cancelled) ~~A means for the implementation of new fast algorithms for complex Walsh orthogonal CDMA encoding and decoding of multiple data rate users over a CDMA frequency band with properties which~~

~~provide a complex Walsh orthogonal code with the real component equal to the real Walsh orthogonal code, and with the imaginary component equal to a reordering of the real Walsh orthogonal code which makes the complex Walsh orthogonal code the correct complex version of the real Walsh orthogonal code to within arbitrary angle rotations and scale factors~~

~~provide complex Walsh orthogonal CDMA codes which reduce to the real Walsh orthogonal CDMA codes upon removal of the imaginary code components~~

~~provide a means to encode and decode multiple data rate users with complex Walsh orthogonal codes for simultaneous transmission over the same CDMA frequency band with computationally efficient algorithm means to implement the encoding and decoding~~

~~provide a computationally efficient algorithm mmeans to encode and decode multiple data rate users with complex Walsh orthogonal codes with values +/-1 +/-j, for simultaneous transmission over the same CDMA frequency band~~

Claim 2. (cancelled) ~~A means for the implementation of new hybrid complex Walsh orthogonal CDMA encoding and decoding of multiple data rate users over a CDMA frequency band with properties~~

~~provide a means for the construction of hybrid complex Walsh orthogonal CDMA codes which are functional combinations of the complex Walsh, discrete Fourier transform (DFT), Hadamard (real Walsh), and other orthogonal codes and which offer wider choices of code lengths~~

~~provide a means to extend the complex Walsh orthogonal CDMA codes to include the complex discrete Fourier transform (DFT) codes and other orthogonal codes to allow greater flexibility in the choices for the code lengths~~

~~provide new fast algorithm means for the encoding and decoding of hybrid complex Walsh codes for multiple data rate users~~

Claim 3. (cancelled) ~~A means for the design of hybrid complex Walsh orthogonal CDMA encoding and decoding of multiple data rate users over a CDMA frequency band with properties~~

~~provide a means to provide greater flexibility in the selection of the code length by combining the complex Walsh orthogonal CDMA codes with the complex DFT orthogonal CDMA codes as well as with other orthogonal codes~~

~~provide a Kronecker product means to combine the complex Walsh orthogonal CDMA codes with complex DFT orthogonal CDMA codes as well as with other orthogonal CDMA codes t~~

~~provide a direct sum means to combine the complex Walsh orthogonal CDMA codes with complex DFT orthogonal CDMA codes as well as with other orthogonal CDMA codes~~

~~provide a functionality means to combine the complex Walsh orthogonal CDMA codes with complex DFT orthogonal CDMA codes as well as with other orthogonal CDMA codes~~

~~provide new fast algorithm means for the encoding and decoding of hybrid complex Walsh codes for multiple data rate users~~

Claim 4. (cancelled) ~~A means to provide unconstrained flexibility in the selection of the code length by functional combining of appropriate orthogonal CDMA codes drawn from a set of code candidates that include the complex Walsh and the complex DFT~~

~~provide a functional means for the generation of orthogonal CDMA codes with unconstrained flexibility in the selection of the code length~~

~~provide a fast algorithm means for the encoding and decoding of CDMA codes designed with a functional means for the generation of orthogonal CDMA codes with unconstrained flexibility in the selection of the code length~~

~~provide a functional means for the generation of orthogonal CDMA codes for multiple data rate users with unconstrained flexibility in the selection of the code length~~

~~provide a fast algorithm means for multiple data rate encoding and decoding of orthogonal CDMA codes which are generated by a functional means for multiple data rate users to provide unconstrained flexibility in the selection of the code length~~

Claim 5. (currently amended) A method for the generation of ~~design and implementation of fast encoders and fast decoders for Hybrid Walsh and generalized Hybrid~~ hybrid Walsh complex orthogonal codes for -CDMA channelization codes ~~for multiple data rate users over~~ and for the plurality of other applications, said methods comprising: ~~a frequency band with properties~~

means for deriving the inphase permutation or reordering of the

Walsh or Hadamard codes which places them in sequency correspondence which is the rate of phase rotation

correspondence with the frequency of the discrete Fourier transform DFT codes and in even code correspondence with the real component codes of said DFT codes,

means for deriving the quadrature reordering of said Walsh or said Hadamard codes which places them in said sequency correspondence with the frequency of said DFT codes and in odd code correspondence with the quadrature component codes of said DFT,

means for using said inphase reordering to generate the inphase component codes of said hybrid Walsh codes, and

means for using said quadrature reordering to generate the quadrature component codes of said hybrid Walsh codes.

~~Hybrid Walsh inphase (real axis) codes and quadrature (imaginary axis) codes are defined by lexicographic reordering permutations of the Walsh code~~

~~Hybrid Walsh codes have a 1-to-1 sequency-frequency correspondence with the DFT codes and have a 1-to-1 even-cosine and odd-sine correspondences with the DFT codes~~

~~Hybrid Walsh codes take values {1+j, -1+j, -1-j, 1-j} or equivalently take values {1, j, -1, -j} with a (-45) rotation of axes and a renormalization~~

~~generalized Hybrid Walsh codes can be constructed for a wide range of code lengths by combining Hybrid Walsh with DFT (discrete Fourier transform), Hadamard and other orthogonal codes, and quasi-orthogonal PN codes using tensor product, direct product, and functional combining~~

~~fast encoding and fast decoding implementation algorithms are defined~~

~~algorithms are defined to map multiple data rate user data symbols onto the code input data symbol vector for fast encoding and the inverses of these algorithms are defined for recovery of the data symbols with fast decoding~~

~~encoders perform complex multiply encoding of complex data to replace the current Walsh real multiply encoding of inphase and quadrature data~~

~~decoders perform complex conjugate transpose multiply decoding of complex data to replace the current Walsh real multiply decoding of inphase and quadrature data~~

Claim 6. (currently amended) A method for the generation of ~~design and implementation of encoders and decoders for complex orthogonal CDMA and~~ generalized hybrid Walsh codes for CDMA and for the plurality of other applications, from code sets which include said hybrid Walsh, said Hadamard, said Walsh, said DFT, pseudo-noise PN, and the plurality of codes, said method comprising: ~~complex orthogonal CDMA channelization codes for multiple data rate users over a frequency band with properties~~

means for generating said codes using tensor product techniques for codes selected from the plurality of said code sets,

means for generating said codes using direct product techniques for codes selected from the plurality of said code sets,

means for generating said codes using functional combining techniques for codes selected from the

plurality of said code sets, and

means for generating said codes using combinations of said tensor product techniques, said direct product techniques, and said functional combining techniques for codes selected from the plurality of said code sets.

~~complex codes inphase (real axis) codes and quadrature (imaginary axis) codes are defined by reordering permutations of the real Walsh codes~~

~~generalized complex codes can be constructed for a wide range of code lengths by combining the complex codes with DFT (discrete Fourier transform), Hybrid Walsh, Hadamard and other orthogonal codes, and quasi-orthogonal PN codes using tensor product, direct product, and functional combining~~

~~fast encoding and fast decoding implementation algorithms are defined~~

~~algorithms are defined to map multiple data rate user data symbols onto the code input data symbol vector for fast encoding and the inverses of these algorithms are defined for recovery of the data symbols with fast decoding~~

~~encoders perform complex multiply encoding of complex data to replace the current Walsh real multiply encoding of inphase and quadrature data~~

~~decoders perform complex conjugate transpose multiply decoding of complex data to replace the current Walsh real multiply decoding of inphase and quadrature data~~

Claim **7.** (new) For said codes in claims **1,2** a method for mapping multiple data rate user symbols onto the code vectors, said method comprising:

means for supporting multiple data rate users with symbol rates from the menu 1/NT,2/NT,. . .,2/T for a N chip said code with a T second chip interval,

means for assigning said users with said like symbol rates to the groups $u_{M-1}, u_{M-2}, . . ., u_1, u_0$ for the respective said menu symbol rates 1/NT,2/NT,. . .,2/T,

means for assigning code indices from the binary indexing fields d_{M-1}, $d_{M-2}d_{M-1}$, . . . , $d_1d_2 \cdots d_{M-2}d_{M-1}$, $d_0d_1d_2 \cdots d_{M-2}d_{M-1}$ to said users in said respective groups $u_0, u_1, , . . ., u_{M-2}$,

means for generating the code index $d=d_0+2d_1+4d_2+...+ (N/2)d_{M-1} = 0,1,2,. . .,N-1$ and for mapping said index onto the N code vectors, and

means for assigning said users to said code vectors using said user index fields and said mapping of said code index onto said code vectors.

Claim **8.** (new) Said codes in claims **5,6** have fast encoding algorithms, wherein a representative fast algorithm for said codes in claim **5** comprising:

means for using said index fields in claim **7** to arrange the input data symbol set in the format $Z(d_0, d_1, . . ., d_{M-2}, d_{M-1})$,

means for performing pass 1 of said fast encoding algorithm by multiplying said Z by the kernal $[(-1)^{\wedge}dr_0n_{M-1}+j(-1)^{\wedge}di_0\ n_{M-1}]$ and summing over $dr_0, di_0=0,1$ to yield the partially encoded symbol set $Z(n_{M-1}, d_1, . . ., d_{M-2}, d_{M-1})$ where $dr_0=cr(d_0)$ and cr(d) is said real axis code for d, $di_0=ci(d_0)$ where ci(d) is said imaginary axis code for d, and n_{M-1} is a

binary code chip coefficient in the code chip indexing $n = n_0+2n_1+. . ., (N/4)n_{M-2}+(N/2)n_{M-1}$,

means for performing passes m=2,3,. . .,M-1 of said fast encoding algorithm by multiplying $Z(n_{M-1}, n_{M-2} . . ., n_{M-m+1}, d_{m-1}, . . ., d_{M-2}, d_{M-1})$ by the kernal $[(-1)\hat{}dr_{m-1}(n_{M-m} + n_{M-m+1})+j(-1)\hat{}di_{m-1}(n_{M-m} + n_{M-m+1})]$ and summing over $dr_{m-1}, di_{m-1}=0,1$ to yield the partially encoded symbol set $Z(n_{M-1}, n_{M-1}, n_{M-2} . . ., n_{M-m}, d_m, . . ., d_{M-2}, d_{M-1})$,

means for performing pass M of said fast encoding algorithm by by multiplying $Z(n_{M-1}, n_{M-2} . . ., n_2, n_1, d_{M-1})$ by the kernal $[(-1)\hat{}dr_{M-1}(n_0 + n_1)+j(-1)\hat{}\ di_{M-1}(n_0 + n_1)]$ and summing over $dr_{M-1}, di_{M-1}=0,1$ to yield the encoded symbol set $Z(n_{M-1}, n_{M-1}, n_{M-2} . . ., n_2, n_1, n_0)$, and

means for reordering the encoded symbol set in the ordered output format $Z(n_0, n_1, . . ., n_{M-2}, n_{M-1})$.

Claim **9**. (new) Said codes in claims **5**,**6** have fast decoding algorithms, wherein a representative fast algorithm for said codes in claim **5** comprising:

means for performing pass 1 of said fast decoding algorithm by multiplying said $Z(n_0, n_1, . . ., n_{M-2}, n_{M-1})$ from claim **8** by the kernal $[(-1)\hat{}n_0dr_{M-1}+j(-1)\hat{}n_0di_{M-1}]$ and summing over $n_0=0,1$ to yield the partially decoded symbol set $Z(d_{M-1}, n_1, . . ., n_{M-2}, n_{M-1})$,

means for performing passes m=2,3,. . .,M-1 of said fast encoding algorithm by multiplying $Z(d_{M-1}, d_{M-2} . . ., d_{M-m+1}, n_{m-1}, . . ., n_{M-2}, n_{M-1})$ by the kernal $[(-1)\hat{}n_{m-1}(dr_{M-m} + dr_{M-m+1})+j(-1)\hat{}n_{m-1}(di_{M-m} + di_{M-m+1})]$ and summing over $n_{m-1}=0,1$ to yield the partially encoded symbol set $Z(d_{M-1}, d_{M-1}, d_{M-2} . . ., d_{M-m}, n_m, . . ., n_{M-2}, n_{M-1})$,

means for performing pass M of said fast encoding algorithm by by multiplying $Z(d_{M-1}, d_{M-2} . . ., d_2, d_1, n_{M-1})$ by the kernal $[(-1)\hat{}n_{M-1}(dr_0 + dr_1)+j(-1)\hat{}n_{M-1}(di_0 + di_1)]$ and summing over

n_{M-1}=0,1 to yield the encoded symbol set

Z(d_{M-1}, d_{M-1}, d_{M-2} . . .,d_2, d_1, d_0), and

means for reordering the decoded symbol set in the ordered output

format Z(d_0, d_1,. . .,d_{M-2}, d_{M-1}).